

## CHAPTER 5

### RECYCLING OF PORTLAND CEMENT CONCRETE

#### 5-1. General.

This chapter provides information and instruction for the preparation of contract specifications and construction operations involving the recycling of portland cement concrete as aggregates in road and airfield pavements. As shown in figure 1-2, portland cement concrete recycling or other methods may correct many types of pavement distress.

#### 5-2. Recycling portland cement concrete procedure.

Existing portland cement concrete when removed as unwanted pavements and structural elements is usually wasted and disposed of outside the project limits. However, the contractor may be given the option of recycling these materials as construction aggregates for portland cement concrete pavement (PCCP), Econocrete, cement-treated base (CTB), and aggregate base (AB). The basic process is shown in the flow chart of figure 5-1. The first step involves preparing the existing pavement or other structural elements for fracturing into pieces of manageable size for the available equipment. The pavement is broken by fracturing with a pavement breaker, scarifying, ripping, or jackhammering. The broken concrete is then hauled to the crushing plant where it is crushed and sized according to specification requirements. The aggregates are then reused directly from the crushing plant or stockpiled for future use. Some of the advantages and disadvantages of recycling portland cement concrete are given in table 1-1.

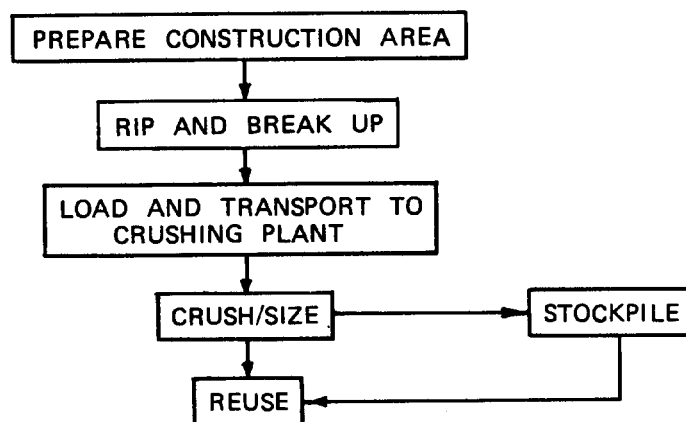


Figure 5-1. Recycling portland cement concrete flow process.

#### 5-3. Sources for recycled aggregates.

Aggregates can be produced from the breakup and crushing of existing portland cement concrete pavement and structural elements.

*a. Pavement.* where an asphalt concrete surface is present on an existing rigid pavement, the asphalt concrete must be removed before the old portland cement concrete pavement is broken up. It is intended that all of the asphalt concrete be removed; however, isolated areas of asphalt concrete up to 1 inch in thickness and small asphalt concrete patches will be considered acceptable. The old portland cement concrete pavement should be removed in a manner that excludes subbase and subgrade material to the maximum extent practicable.

*b. Structures.* It is the intention of this operation to produce the maximum amount of salvage portland cement concrete that can be crushed, stockpiled, and accepted as aggregate in new portland cement concrete. All reinforcing steel should be removed from the salvaged concrete either prior to or during the crushing operation.

#### 5-4. Excess recycled aggregates.

All excess recycled aggregate should be stockpiled for use on other Government projects. If the ownership of the excess recycled aggregate is transferred to the contractor, credit should be given to the Government for its value.

### 5-5. Equipment.

In general, equipment and procedures to handle the crushed portland cement concrete are the same as those for typical aggregates. However, equipment and procedures used to break up, crush, and process existing portland cement concrete for reuse as construction aggregates are unique to the recycling process and, therefore, will be described. Since the major source of recycled concrete is old rigid pavement, most of the pieces of equipment are involved with this operation. Even the equipment used in the recycling process is the type that can be considered standard in heavy construction.

a. *Breakup equipment.* Equipment that has been used successfully to break up existing portland cement concrete pavement includes the following:

- (1) Diesel pile-driving hammer mounted on a motor grader that punctures the pavement on a 1- to 2-foot grid pattern (fig 5-2).
- (2) Concrete pavement breakers of various types.
- (3) Rhino-horn-tooth-ripper-equipped hydraulic excavator frequently employed to dislodge and expose the reinforcing steel after the pavement has been fractured by one of the pieces of equipment described in (1) and (2) above (fig 5-3). The exposed steel is then cut manually with a cutting torch or shears.



Figure 5-2. Diesel pile-driving hammer puncturing the old pavement.

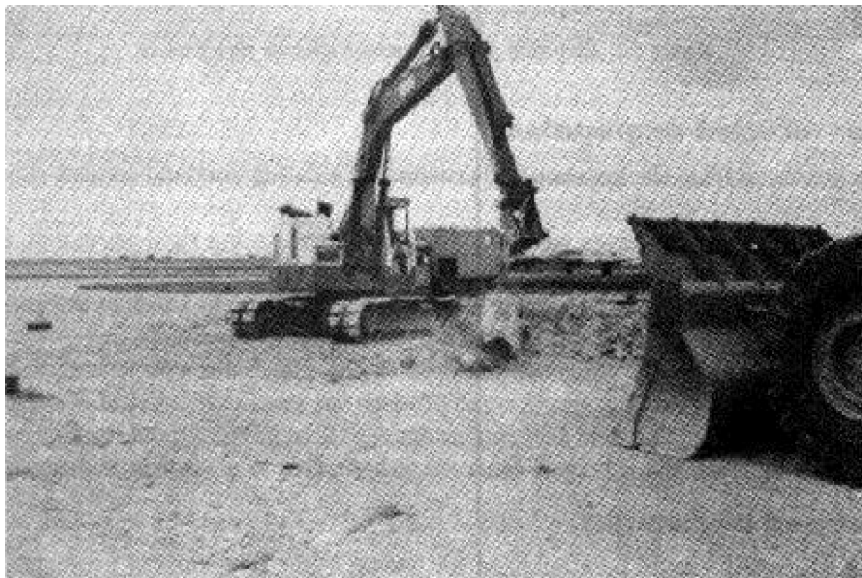


Figure 5-3. Rhino-horn-tooth-ripper-equipped hydraulic excavator.

(4) Old concrete structural elements broken down into manageable pieces by a combination of jackhammers and demolition balls.

*b. Transport equipment.* Cranes and front-end loaders are then used to load the rubble concrete into dump trucks for hauling to the crushing plant.

*c. Crushing equipment.* The crushing plants are either a portable type and located on the job site or a stationary plant situated at an existing pit or quarry.

## **5-6. Crushing process.**

The crushing process consists of breaking the fractured concrete pieces to the required sizes and then stockpiling.

*a. Crushing and screening.* The salvaged concrete is brought to the crushing plant where it is reduced to the maximum size called for in the specifications. The equipment used to crush and size the existing concrete is also a common type used in the construction industry. The crushing equipment should include jaw or cone crushers. The preferred sequence of equipment utilization consists of a primary jaw crusher which breaks the material down to a maximum size of about 3 inches. The secondary cone crusher then breaks the particles down to the maximum size required which, depending upon specification, may vary between  $\frac{3}{4}$  and 2 inches. A hammermill secondary crusher should not be used because of the excess amount of fines such a unit produces. After crushing, the material is separated over appropriate screens and stockpiled separately. A  $\frac{3}{8}$ -inch screen is normally used to separate the coarse from the fine aggregates. The coarse aggregates may be split between fractions under and over  $\frac{3}{4}$  inch. Another screen should be used to scalp off particles above the maximum size specified.

*b. Stockpiling.* The stockpiling should be accomplished in a manner that will prevent segregation and contamination by foreign materials. Each size of aggregate should be stored separately in free-draining stockpiles. Vehicles for stockpiling or moving aggregates should be kept clean of foreign materials. Processing equipment shall include a means by which excessive fines can be controlled so that no more than 5 percent of the fine aggregate passes the No.200 sieve.

*c. Aggregate preparation.* Usually it is not necessary to wash the crushed recycled aggregates unless they are contaminated with base or subbase material. State laws governing pollution control must be observed in the crushing operation.

*d. Reinforcing steel.* Any reinforcing steel not removed previously must be separated from the recycled concrete after it is processed through the primary crusher. The pieces of reinforcing steel should be removed either by electromagnet, suspended above the conveyor belt leading from the primary crusher, or removed manually. The steel will be the property of the contractor and must be removed from the project.

## **5-7. Evaluation and testing.**

These aggregates must meet the requirements for normal aggregates. The recycled portland cement concrete aggregates will be subjected to all tests used to evaluate new aggregates as specified.

## **5-8. D-crack concrete pavement recycling.**

The deterioration of concrete pavement through D-cracking is a fairly widespread phenomenon. D-cracking occurs adjacent to joints and is caused by alkali aggregate reaction and freeze-thaw problems. In order to alleviate the problem, all recycled aggregates from an existing pavement that has experienced this type of deterioration must pass the  $\frac{3}{4}$ -inch sieve if they are to be used as aggregates for a new portland cement concrete pavement. Experience has shown that crushing the reclaimed portland cement concrete to pass through the  $\frac{3}{4}$  inch sieve prevents D-cracks from reoccurring in the recycled pavement.

## **5-9. Fine aggregates.**

To improve workability of a new portland cement concrete pavement using recycled concrete, natural sand can be added to the fine aggregates. But when two or more types of fine aggregates are used, each must be stockpiled separately.

## **5-10. Utilization of recycled aggregates.**

Once the old portland cement concrete has been crushed and stockpiled, and the quality has been found to be satisfactory for its intended use, the material will then be treated as any other aggregate. An applicable document to use as a guide from that point is TM 5-822-7/AFM 88-6, chap 8.